CONTINUOUS PROFESSIONAL DEVELOPMENT
(CPD) FOR SCIENCE TEACHERS

OpenSTEM Africa

GENDER AND SCIENCE

Acknowledgements

Ministry of Education

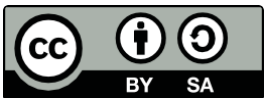
The Ministry of Education, Ghana, for their oversight, support and guidance which has been essential in ensuring that OpenSTEM Africa aligns with and complements other education initiatives and programmes.

CENDLOS, Ghana, for their collaboration and innovation in providing essential avenues for OpenSTEM Africa to reach learners and teachers.

Ghana Education Service, and the expert SHS science teachers, for their expertise in producing materials that are rooted in the Ghanaian school context, accessible and useful to learners and teachers.

For information on OpenSTEM Africa see: www.open.edu/openlearncreate/OpenSTEM_Africa

OPITO for their generous support, which has made OpenSTEM Africa and the development of the Virtual Laboratory and these materials possible.



Contents

OpenSTEM Africa: Ghana

The overarching aim of OpenSTEM Africa, Ghana, is to make a contribution to Government of Ghana/Ministry of Education policy to the effective teaching of practical science.

Effected by:

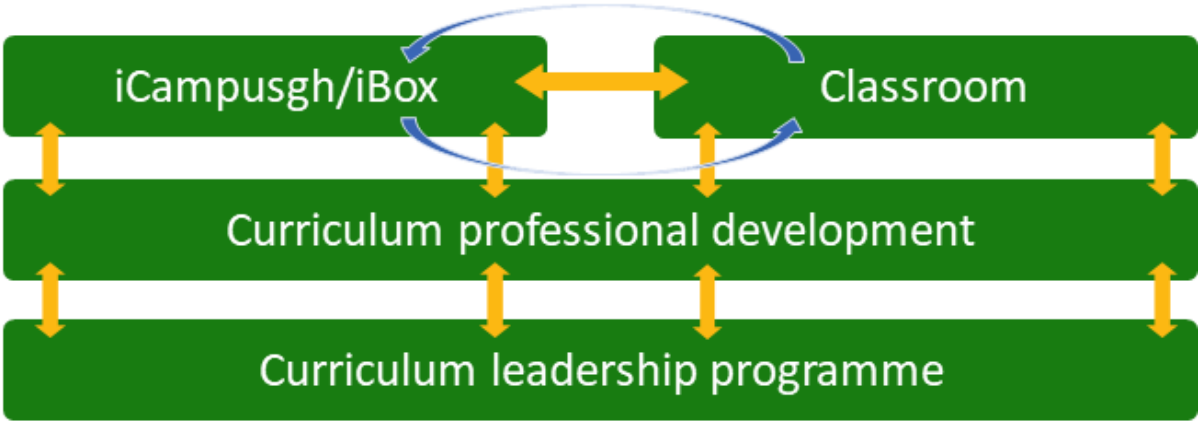
1. **Virtual Lab:** onscreen interactive science instruments using real data and with examples of science lessons, to improve the experiential teaching and learning of science in Senior High Schools, helping develop girls' and boys' practical science study skills, and building on the iCampus/iBox model developed by CENDLOS.

Underpinned by:

2. **Continuous Professional Development (CPD) for science teachers:** which develops confidence, skills and strategies to enable improved teaching and learning in the sciences, with a particular focus on ICT-based practical sciences, and which supports them in meeting the aspirations of the SHS elective science curriculum (Physics, Chemistry and Biology).

Embedded in Senior High Schools through:

3. **Curriculum Leadership Programme:** for Heads of Department/Heads of Subject, which enables them to effectively implement short- and long-term strategies to improve teaching and learning in the sciences, with a particular focus on ICT based practical science in their school.



The school-based professional development and leadership programmes will help more teachers use ICT-based science resources more and more effectively, with more learners. The support for school leaders' facilitates the development of a sustainable community of practice in science within the school, led by the Head of Department/Subject Lead and with the support of the Headmaster/Headmistress, in line with National Teaching Council Guidelines.

CPD programme for SHS science teachers

This CPD programme for SHS science teachers is designed by experienced Senior High School science teachers working with Heads of Science and SHS curriculum and Science Resource Centre developers, representing a wide range of Senior High Schools in Ghana. They are working with representatives from the Ministry of Education, CENDLOS, GES, the University of Ghana and from The Open University (UK) on OpenSTEM Africa: Ghana.

Improving teaching and learning in the sciences at SHS level is part of the Government of Ghana's *Education Strategic Plan (2018–30)* to enable increasing numbers of SHS students to specialise in the sciences at tertiary level and then move into STEM careers. Government of Ghana policy points to the importance of in-service training for teachers for acquiring new skills and keeping abreast of new developments. The National Teacher Standards for Ghana (MoE/NTC) set out the importance of teachers continuing to learn as they teach and the importance of the school as the location of that learning. Ghanaian research suggests that continuous professional development (CPD) taking place within the school is more motivating, more coherent, more sustainable and likely to be more effective in the long term This is the "growth approach in which teachers are given the opportunity to try new opinions, gain new perspectives, and extend their professional capabilities in order to understand and find solutions to problems in their individual schools" (Asare et al., 2012).

SHS science teachers, particularly those specialising in the elective sciences are already experts in their field. This programme is to enable them to work directly with their Head of Science, or Heads of Physics/Biology/Chemistry alongside their departmental colleagues to further develop the expertise of the whole department in teaching SHS sciences, with a particular focus on ICT-based teaching and learning and to help build a community of practice among science teachers in the school.

Gender and science

The CPD units can be found at: https://www.open.edu/openlearncreate/CPD_units

Why does gender matter for Science teaching?

Teachers in Ghana are required to ensure that all learners have access to learning, and to recognise and understand particular barriers that are gender based. The following extract from the National Teachers Standards' shows how this is embedded into national policy.

The teacher:

Investigates and takes notes of each learner's background, acknowledging where they may have gaps in their education, extra domestic work (especially for girls), be vulnerable to early drop out and act on this to overcome disadvantage; they know why some learners may have irregular attendance and seek to improve this; they code-switch as appropriate to ensure all can understand lesson content; seat learners carefully to support one another; talks with respect about all learners; draws sensitively on learners' backgrounds in their teaching.

(*National Teachers' Standards,* 2017)

This unit aims to support teachers in ensuring that girls can maximise their potential for Science learning. In this section you will read some background material to gain a better understanding of why gender differences continue to exist within Science teaching. Despite policies and campaigns to increase awareness, there are still those who do not see this as a problem, or do not understand the implications of lack of girls and women within Science education and the scientific workforce. So we will start with asking the question:

Why does gender matter for science teaching?

There are different types of arguments that you might have heard for increasing gender equality in STEM.

1: Inequality in science education leads to unequal opportunities in science employment. Science learning can lead to better economic outcomes for girls and women

This first point is about equality of opportunity, which is based on a human rights approach.

"The equal right of men and women to the enjoyment of all economic, social and cultural rights."

(Article 3, UN Covenant, Human Rights)

If girls are educated to the same level as boys in STEM subjects, they will have greater opportunity to work in well-paid jobs and realise their own potential. There are new occupations and careers that require advanced STEM skills, but existing sectors are also transforming through rapid advancements in technology and will need higher level STEM knowledge and skills. So, for girls and women who are competent and qualified in STEM subjects, their employment options are increasing, and they can embark on meaningful and well rewarded careers.

2: Science benefits from a diverse workforce to create innovations/solutions that benefit everyone

The second set of arguments are about the economic and social benefits to society as a whole. Women with STEM education can fill skills gaps and enable greater prosperity for their communities as well as the nation. Moreover, a diverse workforce leads to better design and decision making. In other words the inclusion of women at all levels in the STEM workforce leads to better products and more effective business. When women are excluded, this can have major negative consequences.

Stanford University in the USA have developed a set of examples which illustrate the importance of making sure women are included in STEM innovations. Their website Gendered Innovations gives examples of products and discoveries that have not taken women into account, therefore potentially causing harm by neglecting the needs and experiences of women. For example: car safety design was for a long time tested on crash-test dummies that were considered to be a standard size and shape. However, it was only after figures revealed the high rate of foetal deaths in crashes involving pregnant women that safety tests started to include models of pregnant women.

Gender bias can even be embedded in software and artificial intelligence (AI). Algorithms which underpin many computer products have to be 'trained' with existing data and very often the sets of data that are used will reproduce the kinds of biases which already exist in society (Zou and Schiebinger 2018), including racial bias with, for example facial recognition software more likely to misclassify gender for darker skinned women compared with lighter skinned men (Buolamwini and Gebru, 2018).

3: Scientific knowledge is often produced from the point of view of white European or North American men – understanding of gender can help see things from a different point of view and enrich knowledge

Many people assume that scientific knowledge is value free, but Western narratives of scientific discovery often use stories of famous white men and ignore the contributions of women to these insights. These stories also ignore how the development of Science and technological progress has built on the exploitation and colonial power of European nations. The knowledge and insights from indigenous cultures has often been unrecognised and dismissed. Many groups have worked to make women's contributions more visible. For example, Ursula Burns, as a mechanical engineer and the CEO of Xerox, was the first African American woman to lead one of the top 500 companies in the USA. There are also women across the continent of Africa who are powerful African scientists changing the world.

So why are girls and women underrepresented in STEM?

We know that girls are less likely to continue studying STEM subjects when they reach Senior High School. The transition to tertiary education is also a key point at which girls and young women tend to leave STEM.

It's important to note that the picture is not the same across all STEM subjects – biological science tend to have more women students, while engineering is much more male dominated (Cheryan et al., 2017). Patterns of gender participation also differ from one country to another (in Iran, Saudi Arabia, Malaysia etc. there are more women studying STEM (UNESCO, 2012) and in India about 50% of graduate entries into the IT sector are women (Raghuram et al., 2018).

There has been a lot written about the underrepresentation of women in science, and there are a number of explanations given. What is clear is that there is not any innate difference between the abilities of girls or boys when it comes to mathematics or scientific thought (Ceci and Williams, 2009). The answer lies in the culture which influences and shapes the possibilities and choices that girls and women make in terms of study and career/employment. Within this there are factors that are individual – the way that girls and women views themselves, their identity and what they see as possible and relevant in their own lives, as well as external factors such as parents, teachers, peers and the kinds of work and careers which are actually available to them.

A study by Quansah et al. (2020) of high school students in Ghana reveals that school-related factors, such as the programme of study, elective mathematics status and interest in mathematics and science, influences female students' choice of STEM programmes in tertiary education. However, it is not just school factors that influence these outcomes. Home factors (e.g., the level of education of parents or their socioeconomic status) and personal factors (e.g., self-confidence, career indecision, having a role model in STEM) also play a significant role in female students' choice of STEM programmes in their tertiary education (Boateng and Gaulee 2019).

Reflection point

Think about your own experience of being at school or university. How has your gender affected your progress both in your studies and in your career?

How have attitudes of friends and family affected your choices?

In the OpenSTEM Africa CPD unit *Linking Science to everyday life*, you will have read the classroom example of cooking, repeated below, to help challenge the gender stereotype of associating cooking with women's work, as well as to remind us that professional chefs as well as professional scientists are actually often assumed to be men!

Classroom example 1

Mr Ako Nai Otoo was concerned that some students in his Biology class still considered cookery and food preparation in the home as a domestic activity, unrelated to the outside world and mostly carried out by the female members of the household. While the class were studying Biology SHS3 Section 3 Unit 3 on Biology and the Food Industry, he decided to give homework to encourage all in the class to see food preparation and food preservation in the home as a strictly scientific activity.

- He asked the class to consider local methods of preserving food e.g., drying, salting, smoking (wet hot smoking and dry hot smoking) and to ask their parents, grandparents and other family members for information about preserving fish.
- He made clear that this task would be an individual one for each member of the class – to carry out themselves, and to document the process
- He said that the homework consisted of each individual preserving a fish, using local and family practices of their choosing.
- Each student needed to source a small fish, e.g., a tilapia, decide how to preserve it, and give themselves a maximum of seven days to carry out the process and write up the biological processed involved.
- He told the students they should aim to include photos or videos as part of their documentary evidence.
- At the end of the seven days, each student needed to provide a written report, in which they documented the advantages and the challenges of the method they chose, discussed the biological basis of their method of food preservation and storage, and analysed how their method of food preservation enabled the destruction (or prevented the multiplication) of micro-organisms in the fish.

Activity 1: Planning active writing activities

Working with your Head of Department/Head of Subject and colleagues, reflect on the above example and then think of classroom activities where the girls are included/lead on a science experiment which is more traditionally seen as a male activity.

How many examples can you think of as a group?

Examples could be related to mining, for example, the science involved in driving heavy machinery, piloting commercial aircraft, the large-scale construction of a civil engineering project such as a bridge or multi-storey office building.

Challenging stereotypes and gendered language/representation in the curriculum

I see scientists as white men doing experiments in their lab coats.

(Mbajiorgu and Iloputaife, 2001)

What are stereotypes and how does this affect Science identity?

A stereotype is:
"a standardised mental picture that is held in common by members of a group and that represents an oversimplified opinion, prejudiced attitude, or uncritical judgment."

(Oxford English Dictionary)

Stereotypes can have a powerful effect on whether individuals feel that a career or even a subject for study is suitable for them. In particular, gender stereotypes are very strongly associated with roles in work as well as within the family and communities. So, what have stereotypes got to do with women in Science? Research has shown that career choices are affected by the notion of self-concept and identity. Stereotypes about jobs are often strongly associated with one gender or another, regardless of the actual nature of the work involved. There are strong and enduring stereotypes associated with 'who does Science'.

Many experiments have been carried out using a method called 'Draw a Scientist' to demonstrate that young children already have stereotyped views of who can become a scientist. This may be because of the people who they see around them in particular roles, or messages they get about the suitability of certain subjects or professions for girls or boys. These are reinforced by popular culture, so images which originate in Western culture often depict in popular children's TV and cartoons a typical scientist as an old white man in a lab coat with disheveled hair and glasses (Meyer, Guenther & Joubert, 2019).

If you want to know more about the Draw a Scientist activity or try it out with your class, you can read about one teacher's experience of doing this with her students in the NSTA article *Draw a Scientist: Uncovering students' thinking about science and scientists.*

Stereotypes also have another effect on learning. Research has shown that school children will conform to stereotyped expectations of their ability and exam performance. For example, experiments have been carried out where groups of girls and boys take a maths test at the same time – where before the test, one group were told about gender gaps in STEM while the other group did not get this information. In the first group the girls did less well in the test than the boys while in the second group there were fewer differences. This is known as 'Stereotype Threat'. You can read more about Stereotype Threat in the American Psychological Association article on the subject.

Reflection point

What are/were your own stereotypes about scientists – as a child, as a student, and now as a teaching professional?

When did you first encounter an image or representation of a women scientist/African scientist?

Gender stereotypes can also continue through the use of gendered language in teaching materials, often without this being the intention of the author/teacher.

The European Institute for Gender Equality has resources which can be of help in understanding how and where to spot gender-discriminatory language (European Institute for Gender Equality, 2019). The institute has identified three broad categories:

- stereotypes (for example, assigning gender when it is unknown or irrelevant)
- invisibility and omission (e.g., language that casts men as the generic norm and keeps women as invisible)
- and subordination and trivialisation (language which depicts women as inferior or belittles them).

Their toolkit includes a number of checklists and resources.

In preparing these CPD units, the OpenSTEM Africa team used the checklist shown in Activity 2 to review the first draft of the teaching materials. We then gave feedback to the authors who were able to make changes for the final version. You might like to try this with some of your own materials.

Activity 2: A review of materials

Use the checklist below to look at your lesson plans and teaching materials. You could do this with another teacher and provide feedback on each other's materials.

Power

- Are men portrayed in positions of power/women subordinate?
- Word order – are men/boys always mentioned first?
- Pronouns – is there a gender balance, can they replaced by the neutral 'they/them'?

Stereotypes

- Do case studies/examples represent both men and women?
- Do case studies include issues or examples that are appropriate and relevant to girls as well as boys? For example, using health rather than engineering issues to explain concepts.

Image

- Is there gender balanced representation in images?
- Are images reinforcing stereotypes?
- Are any role models of women in Science included?

Activity 3: Brainstorming and making a mind map

Find and use resources that show girls in non-stereotypical roles (e.g., Integrated Science SHS1 Section 1 Unit 1, references a soil scientist, a medical doctor and a geologist – all of whom could be women). Try to be aware of your own gender stereotyping; you may know that girls play sport and that boys are caring, but often this is expressed differently, mainly because there are stereotypical ways of talking in society.

The following checklist was developed in the UK by researchers who were looking at ways to increase the participation of girls in Physics. You might find some useful tips in this. Read through and make notes about ideas that you could put into practice in your own school.

4.3 Checklist: How inclusive is your physics teaching?

The following questions and prompts are intended to help school science departments and individual teachers to reflect on their own practice in relation to the teaching of physics to girls.

Departments

- Do you really believe that girls can do as well as boys in physics? Is this reflected in conversations with female students about their aspirations and choices?
- Have you spoken to careers staff to make sure that they are aware of the full potential of physics qualifications and present a positive view of the subject to girls?
- Does the school website or booklet information about choices give potential physics students of both genders a positive view of the subject, its breadth and the benefits of further study?
- Do you use successful post-16 students of both genders to inform GCSE candidates about their experience?

Individual teachers

Planning

- When planning, do you try to make explicit the links between lessons and topics in order to explain "the big picture"?

Classroom organisation

- Have you tried single-gender groups for discussion and practical work? Have you given students specific roles during these activities to ensure full participation?

Questions and discussion

- Do you use a variety of questioning techniques, including a growing proportion of open questions requiring an extended response?
- Are students given sufficient thinking time and the opportunity to discuss their ideas with peers?
- Do you encourage small group as well as individual responses (after brief "talk time")?
- Have you tried individual whiteboards for quick individual response gathering?

Language

- Do you use technical language only when essential and reinforce it by using it in context?
- Are students encouraged to use their own language to explain their ideas, before being introduced to the specialist vocabulary?
- Do you avoid "talking equations"?

Illustration and analogy

- Are you careful to use a range of illustrations that draw on the interests of girls as well as boys?
- Do you encourage students to use their own analogies (while reminding them of the limitations of analogy)?

Relevance

- So that work has a clear rationale, do you make a point of following the sequence: applications; principles; applications?
- Do you supplement standard texts with other reading materials, such as articles and newspaper cuttings?
- Is the Internet used to introduce contemporary applications of physics?

From Institute of Physics Girls in the Physics classroom: A teachers guide for Action (2006 pp. 6–7)

Gender and behaviour in the classroom

Behaviour and how this is managed within the classroom can affect how girls experience Science learning and could potentially lead to them feeling less confident and less likely to progress to higher levels of study. For example, some girls are less likely to put up their hands to answer a questions.

Assumptions about what is appropriate for girls and boys (stereotypes) can limit the ambition and attainment of girls. Teachers may unconsciously be reinforcing stereotypes or gendered patterns of behaviour. Earlier in this unit, you read how Stereotype Threat can lead to girls underperforming if they assume the researcher is expecting them to perform more poorly in a maths test.

In other research, teachers found that in mixed groups, boys tended to rush into practical activity while girls often wanted to draw up tables for results or carry out other preparatory work before starting an experiment. When working in groups, this can lead to boys doing the actual experiments while girls are more likely to become the notetakers.

You might be familiar with girls saying something like *"we like to think things through and know what we've got to do. Boys just jump in and don't seem to worry if they get it wrong."*

The questioning technique that teachers use is a crucial factor in engaging girls in Science. In a mixed class, boys will almost always be the first to respond to a request for "hands up" to answer a question directed at the whole class. By allowing thinking time, you can avoid instant responses, which typically come from boys.

A reminder of some ideas from the other OpenSTEM Africa CPD units (e.g., *Effective questioning*, *Collaborative learning* and *Feedback and feedforward to improve learning*) which are designed to increase the participation of girls:

- Change the seating in the class regularly ensuring that girls as well as boys sit at the front.
- Decrease the use of hands-up, closed, rapid-response questions.
- Encourage the view that there is not always a unique correct answer.
- Give students the privacy and confidence to take risks when answering questions.
- Invite pair and group discussion with a spokesperson (female as often as male) as a way of lowering the stakes and encouraging collaborative learning.
- Pair and group work should be all female/all male some of the time, as all female groups can encourage the girls to speak up and speak out in their own pair/group.
- Pair and group work should be mixed female and male some of the time as this accustoms everyone to girls leading discussion and speaking on behalf of the pair/group.
- Evidence from research shows that girls still receive less teacher attention in science classes than boys.
    - Teachers are more likely to allow boys to dominate discussion as a means of controlling their behaviour
- Teachers' beliefs about student abilities have a significant effect on how students view their own abilities. There is evidence that teachers have lower expectations of girls in physics, even those girls who continue to specialise in physics at SHS and who want to study physics at tertiary level.

Below is a classroom example from the OpenSTEM Africa CPD unit *Involving all* which has been adapted include a more specific gender focus.

Classroom example 2

Example about gender stereotyping and high expectations.

High expectations and gender

Mrs Sarfo is a highly experienced teacher with both a bachelors and a masters degree in Physics. She is aware from her own experience how few women teach Physics and how few girls choose Physics as a subject at tertiary level. She wants to do all she can to encourage more girls to gain the confidence to choose the subject which she loves. She was teaching her students about the mass spectrometer. She decided to use a strategy called 'pair-think-pair-share'. She drew a diagram on the board and used it to explain the steps. When she had finished talking, she wrote the steps on the chalkboard, but put them in the wrong order.

She numbered the steps and divided the class into pairs ensuring that each of the female students was paired with another female student and that struggling female students were paired with high achieving female students who could support them.

- Step 1 was that the pair explained to each other the task (Pair).
- Step 2 working on their own, each student in the pair had to work out the correct order by jotting the numbers on a piece of paper.
- Then Step 3 they compared their answers with their partner in the pair (Think).

If they did not agree, they had to explain their reasoning and agree the correct order (Pair). Then they had to share with another female pair and discuss the problem until they all agreed (Share). Once everyone had agreed the correct order, students copied the sequence into their notebooks.

Did you notice…

In this way she used pair work as an opportunity for female students to interact only with other female students and enabling high achieving female students to support those who would find the work more difficult, while maintaining high expectations for everyone in the class. While this type or pairing needs preparation the first time it is used, then once it is established (as ONE of the types of pair in pair work) then it is simple to adopt it with the class when it is needed next time.

Career choice: Role models and raising aspirations

Role models

The importance of role models has been well explored by researchers and is an important strategy that has been used to increase girls and women's participation in STEM globally. We saw earlier that the 'Draw a Scientist' activity reveals how internalised stereotypes of who can be a scientist are formed even at a very young age. To combat this, it's important to try and include women, and particularly African or Black women of African heritage from other countries. In other words – people who the girls can relate to and aspire to become.

Activity 4: Using the power of role model

Write a list of role models, inspirational women in STEM who you would love to invite to come and inspire girls at your school.

You may find it useful to compile a list of your school's alumni who went on to university and might like to come back and give a talk.

Organise a session for girls and their parents to come and find out about careers in Science, using the People Like Me model.

Encourage your students to do their own research into inspirational Ghanaian women scientists. They may find the following women a good place to start:

- Marian Ewurama Addy
- Larisa Akrofie
- Marian Asantewah Nkansah
- Priscilla Kolibea Mante
- Regina Honu

Careers in STEM

It's important to tell career stories that illustrate the journey those individuals have undertaken to reach where they are now.

Information about new and emerging careers using STEM qualifications are also vital, as many young people (and their parents) may have a very limited idea of what careers are available with a STEM degree.

Don't forget that parents are one of the strongest influences on young peoples' career choices. Often their knowledge of careers is limited to traditional occupations – doctor, nurse or teacher. Meanwhile, engineers are often viewed in a very traditional sense, involving physical labour and getting very dirty. In reality, many healthcare roles involve technology and science, and software engineers and programmers are hugely in demand across the technology sector. The perspective of parents can differ from one country to another. For example, in India where women form up to 50% of the new recruits into the IT sector, parents consider computing to be a great job for their daughters, in nice clean offices and providing perks such as transport and childcare as well as great salaries.

Resources

- Initiatives that promote/support advancement of girls in STEM – e.g., AIMS: https://aims.edu.gh/
- Ghana contacts list: https://docs.google.com/spreadsheets/d/1L1EwgGFtllseJB2NwRrmtyF3N-v56VCmZ5O6lHYCH6g/edit#gid=1750253098
- UNESCO and other examples search: https://www.google.com/search?q=unesco%2C+ghana%2C+stem+clinics+for+girls&rlz=1C1GCEV_enGB950GB950&oq=unesco%2C+ghana%2C+stem+clinics+for+girls&aqs=chrome..69i57.16462j0j15&sourceid=chrome&ie=UTF-8

Supporting girls into STEM – what you can do

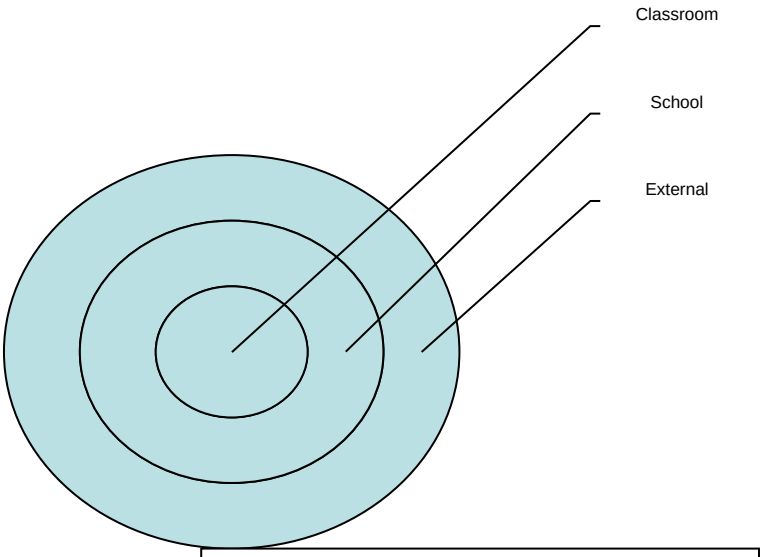
In this final section you are encouraged to develop an action plan to take the next step in developing your practice and making a difference.

You have reviewed the evidence that shows why girls are less likely to take up STEM studies at higher level in school and university and should now understand how you can play a part, however small, in helping to change this.

Activity 5

Either individually, or in discussion with your colleagues, write an action under each of these headings, identifying what you can do next to make a difference:

- In your classroom
- In your school
- Using your networks and contacts outside of the school
- Influencing practice of other teachers.



For each of these identify what are the next steps, for example:

- Do you need to work with your Head of Department and with them ask for the support of your Head of School to consider the value of these?
- Who might help you and who might get in your way?
- Do you need any extra resources or can this be done within your current working practice?

Summary

This unit has encouraged you to think about your behaviours, your attitudes and your teaching. You will not be able to involve all your female students in every lesson, but over time it is possible to make all female students feel included, through a variety of approaches including the ones in this unit and the other CPD units including *Formative assessment*, *Effective questioning* and *Collaborative learning*.

The gender-inclusive behaviours described in the first part of this unit apply to all teachers and are reflected in the way the school in organised. Continue to work with your Head of Department and colleagues to review gender and the treatment of female students in your department and school to see how it can be improved.

A full list of the OpenSTEM Africa CPD units can be found at:
https://www.open.edu/openlearncreate/CPD_units

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Acknowledgements

Grateful acknowledgement is made to the following sources:

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